Practical Application of Ergonomics

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HFES Strategic Planning Study

- Reviewed ergonomics research and practice around the world to determine common characteristics, purpose, and scope of ergonomics
- Some important findings and conclusions are as follows

Ergonomics is a Scientifically Based Discipline

- Science
  - Study human performance capabilities and limitations.
  - Apply our scientific knowledge of humans to developing ergonomics technology
    - Principles
    - Guidelines
    - Specifications
    - Methods
    - Tools

Ergonomics is a Scientifically Based Discipline

- **Practice***

  Apply ergonomics technology to the design, analysis, test and evaluation, and standardization of systems.

- **Purpose***

  To improve the quality of human life
  - Health
  - Safety
  - Comfort
  - productivity

* *HFES Directory and Yearbook*: Strategic Plan

The Technology of Ergonomics is Human-System Interface Technology*

Human-System Interface Technology

- Human-Machine: Hardware Ergonomics
- Human-Environment: Environmental Ergonomics
- Human-Software: Cognitive Ergonomics
- Human-Job: Work Design Ergonomics
- Human-Work System: Macroergonomics

* *HFES Directory and Yearbook*: Strategic Plan

Good Ergonomics is Good Economics

- **Poor Ergonomics**
  - Violates ergonomics technology and/or
  - Is not cost effective
- **Good Ergonomics**
  - Appropriately applies sound ergonomics technology and
  - Is cost effective

ERGONOMICS Must Be COST EFFECTIVE

The language of business is *money!*

- **Managers have to justify any expenditure in terms of the cost-benefit ratio: How the project will affect the bottom line.**
- **Must express ergonomic project proposals in financial terms.**

Measuring the Economic Costs and Benefits of Ergonomic Interventions

- **Costs**
  - Personnel, training, equipment, materials, reduced productivity, and overhead.

- **Benefits**
  - Personnel savings: Less lost time, less training, lower skill levels required, increased output per person, fewer people required, greater individual or team effectiveness.
  - Material savings: Reduced scrap, fewer rejects, fewer parts.

Measuring the Economic Costs and Benefits of Ergonomic Interventions

- **Source of information**
  - Much of the cost and pricing information is available through either your human resources or accounting departments, including overhead percentage.
  - Projected benefits can be gained through the literature and looking at similar projects in other organizations.

Measuring the Economic Costs and Benefits of Ergonomic Interventions

Example: Tractor Forwarding Units, South African Forestry Industry

<u>Original Unit</u>: Poor operator seating and visibility

Measuring the Economic Costs and Benefits of Ergonomic Interventions

Example: Tractor-Trailer Forwarding Units

South African Fo
Industry

Redesigned Unit: Good opera
seating and visibility

Measuring the Economic Costs and Benefits of Ergonomic Interventions

Example: Tractor-Trailer Forwarding Units, South African Forestry Industry

Cost

- 23 Units modified @ $300 per unit: $6,900

Benefit

- Reduced accident damage by $2000 per unit per year or $46,000 per year.
- Extraction increased by one load per day per vehicle for total increase of $19,000 per yr
- **TOTAL Cost-Benefit:** $58,100 or 1 to 9.4 C-B ratio.

Measuring the Economic Benefits of Ergonomic Interventions

- **Less Tangible Benefits**
  - **Increased Employee Satisfaction and Commitment :** Leads to "good citizenship" behavior. Can reduce grievances, improve productivity, and improve troop-community relations – all of which can have a positive financial impact.
  - **Improved Organizational Image:** Can result in less governmental scrutiny & better community relations – all of which can have a positive financial impact.

Cost Effective Ergonomics

- The earlier ergonomics is used in design, the cheaper the cost and greater the benefit*

System Development Design Stage	Proportion of Engineering Cost
Conceptual/Early Design	1.0%- 2+ %
Blueprint	1.5%- 3+%
Construction	2.0%- 6+ %
Commissioning	4.0%-10+ %

Cost Effective Ergonomics

Average Cost of Effective HFE Programs

- **1.0% of engineering design/development budget** - based on analysis of 10 major military system development projects (Hendrick & Jones, 1981).
- **1.0% of engineering design/development budget** – based on analysis of 15 projects (Alaxander, 2000).
- **0.08% of acquisition cost of off shore platforms** -based on analysis of several platform development programs over 9 year period (Miller, 1999).

Cost Effective Ergonomics

- **Typical Cost-Benefit Ratio of HFE Programs**
  - **Between 1 to 2 and 1 to10+ (direct cost savings only) – based on analysis of 27 projects (Hendrick, 1997*).**
  - **Life cycle cost savings can make the cost-benefit ratio in excess of 1 to 50 (Hendrick, 1979; 1997).**

***Good Ergonomics is Good Economics* (available in pdf format at no cost at http://hfes.org).**

Personal Example: C-141 Aircraft System Development Program

C-141 Aircraft Development Program

- Four Engine USAF Cargo Aircraft
- Converts to different configurations via installation of kits:
  - Cargo aerial delivery
  - Paratroop
  - Passenger aircraft
  - Medical air evacuation

C-141 Aircraft Development Program

- Conducted macroergonomic analysis of operational work system.

Results

- Original design: Kits had many parts that would never be removed from aircraft.
- Redesigned kits to only include items that would not be left in aircraft

C-141 Aircraft Development Program

- Saved $2.5 million in original price
- Kits smaller, lighter, easier to store and could be installed faster with fewer people
- Saved storage cost and reduced personnel requirements.
- Reduced actual aircraft operational weight and related fuel costs for entire fleet of over 200 aircraft over 35+ year period.

C-141 Aircraft Development Program: Total HFE Cost-Benefit

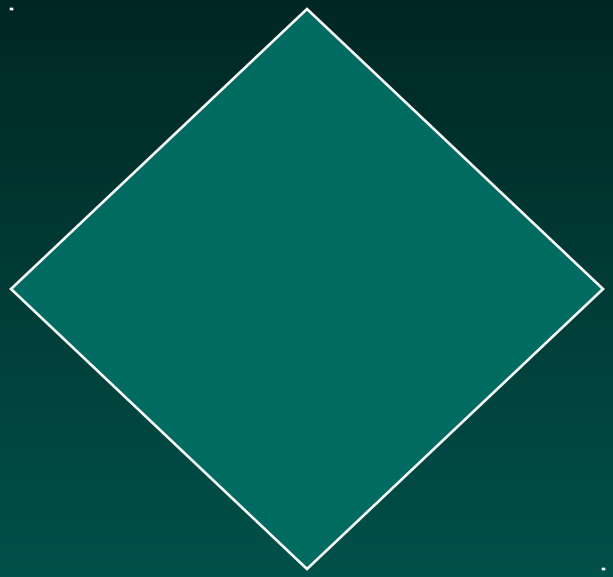
- Over 100 ergonomic improvements to original engineering design
- Direct savings of over $5 million for HFE program cost of $500,000 – a 1 to 10 cost benefit ratio.
- Life cycle savings from ergonomic improvements: At least 1 to 50 cost-benefit

C-141 Aircraft Development Program: Total HFE Cost-Benefit

- Good example of what ergonomics can do when integrated with engineering design early in the development program.

Ergonomics Cost-Benefit Trade-Off Diamond

Human-System Interface Design



Training

Selection

Job Performance Aids

Ergonomics Cost-Benefit Trade-Off Diamond

- Often overlook ergonomic design and job aids.
- Managers & commanders tend to overemphasize training and selection as the cure – does not eliminate poor ergonomic design!

Ergonomics Cost-Benefit Trade-Off Diamond: Job Aid Solution

- Example: IBM Displaywriter Packing Line
  - Frequent errors in packing caused customer set-up of the product to fail.
  - Ergonomist analyzed problem and developed large story board aid for each packing station.
  - Boards detailed & illustrated specific packing steps.

Ergonomics Cost-Benefit Trade-Off Diamond: Job Aid Solution

- Example: IBM Displaywri
  Packing Line Storyboard

Management Awareness is Critical

- Study by Ed Jones and myself of DoD Major System Development Programs.

  - Evaluated major DoD system development programs over a 10 year period in terms of whether they had a good or poor ergonomics development effort.

  - Found those with a poor effort had major problems when they became operational.

  - Looked for what made the difference between those with a good effort vs. those with a poor effort.

Management Awareness is Critical

- Study by Ed Jones and myself of DoD Major System Development Programs.

  Results:

  - Major discriminating factor was ergonomics awareness of the program director/commander.

  - Aware commanders appreciated value added of ergonomics -- and so allocated personnel resources and funding to ergonomics. Those lacking knowledge of ergonomics did not .

Management Awareness is Critical

- Study by Ed Jones and myself of DoD Major System Development Programs.

  Results:

  - **Effective programs:** Ergonomics was an integral part of the engineering design team.

  - **Ineffective programs:** Ergonomics was treated as an “ility”, like reliability, maintainability, etc.; only could make input after item was already designed (band-aid changes only).

Management Awareness is Critical

- Study by Ed Jones and myself of DoD Major System Development Programs.

Lesson

Establishing rapport with key managers and raising their consciousness about ergonomics is essential to your long-term success.

This often takes time and persistence!

Participatory Ergonomics is Essential!

Participatory ergonomics: Involve employees at all levels to insure success.

- **They know problems with their jobs best.**
- **They know what ergonomic alternatives will be most satisfying and acceptable to them.**
- **Get employee "buy-in" to changes.**
- **Establishes a true ergonomic safety culture – the proven way to sustain improvement gains!**

Example: Participatory Ergonomics

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Stadiu

Example: Participatory Ergonomics

- Food Service Stand Redesign: Dodger Stadium

Results

- Ergonomists Andrew Imada and Gorge Stawowy redesigned two food service stands for a cost of $40,000 using participatory ergonomics.

- Reduced average customer transaction time by 8 seconds.

Example: Participatory Ergonomics

- Food Service Stand Redesign: Dodger Stadium

Results (continued)

- Increased productivity was $1,200 per baseball game, resulting in payback period of 33 games.

- Payback period for modifying the other 50 stands will be 20 games.

OSHA Guidelines* are the Key to an Effective Ergonomics Program

- Are based on extensive research
- When OSHA ergonomics program elements not present, ergonomics & safety program invariably not adequate.

*See OSHA 3123 *Ergonomics Program Management Guidelines for Meatpacking Plants*

OSHA Guidelines are the Key to an Effective Ergonomics Program

OSHA Guidelines

I. Management Commitment & Employee Involvement

- A. Commitment by Top Management - deeds, not just words
- B. Written Program
- C. Employee Involvement
- D. Regular Program Reviews & Evaluation

OSHA Guidelines are the Key to an Effective Ergonomics Program

II. OSHA Program Elements

- A. Worksite Analysis
- B. Hazard Prevention and Control
  - Engineering Controls
  - Work Practice Controls
  - Personal Protective Equipment
  - Administrative Controls

OSHA Guidelines are the Key to an Effective Ergonomics Program

II. OSHA Program Elements (Cont.)

- C. Medical Management
- D. Training and Education
  - General Training
  - Job-Specific Training
  - Training for Supervisors
  - Training for Management
  - Training for Engineers & Maintenance Personnel

OSHA Guidelines are the Key to an Effective Ergonomics Program

- **OSHA Guidelines**

  - **Poor Example: Some warehouse Retail Stores – Program elements largely missing; many customer injuries.**

  - **Good Example: Redwing Shoes**

Insuring Effective Ergonomics

- **OSHA Guidelines: Redwing Shoes**
  - Implemented OSHA guidelines components.

  Results
  - From 1989 to 1995, workers compensation dropped by 70% for a $3.1 million savings.
  - OSHA reportable injuries dropped from ratio of 75 per 100 employees working per year, to 19.

Macroergonomics: The Key to Dramatic Improvements

Macroergonomic interventions can dramatically improve health, safety, and productivity (50% - 90% or more).

Theoretical Basis

- **Systems theory:** All complex systems are synergistic: When harmonized, whole more than the sum of its parts.

- Sociotechnical systems thus are more than the sum of their parts.

- Therefore, macroergonomics can dramatically improve the effectiveness sociotechnical systems.

Macroergonomics: The Key to Dramatic Improvements

Macroergonomics

- **Conceptually: A top-down sociotechnical systems approach to work system design**

- **In Practice: It is top-down, middle-out, and bottom-up (via participatory ergonomics).**

Macroergonomics: The Key to Dramatic Improvements

Goal: Achieve a fully harmonized work system

1. Design a work system's structure and processes to be compatible with the key characteristics of its
   - Personnel subsystem
   - Technological Subsystem
   - External Environment

   Empirical models exist that enable us to accomplish this.

2. Design jobs, human-machine, human-software, and human-environment interfaces to fully harmonize with the over-all work system design

Macroergonomics: The Key to Dramatic Improvements

Macroergonomic interventions possible when:

- A major change in equipment, facilities or processes is to take place.
- The organization is in real trouble.
- There is an enlightened management regarding ergonomics.
- Micro-ergonomic successes have gained you management's confidence.

Macroergonomics: The Key to Dramatic Improvements

Result

- A fully harmonized work system.
- Whole thus is more than a simple sum of its parts – *Synergistic*.
- Consequently, dramatic improvements occur.

Example: Large Petroleum Distribution Company in U.S.

Macro- and Micro-ergonomic Intervention

Example: Large Petroleum Distribution Company in U.S.

Macroergonomic Intervention

- Macroergonomic analysis of work system.
- Developed strategic plan for improving safety & productivity.
- Made changes to work system where indicated.
- Participation at all levels.

Example: Large Petroleum Distribution Company in U.S.

Micro-ergonomic Intervention

- Worker participation at all levels.
- Employees (with ergonomist facilitator/resource person)
  - developed and taught truck safety program
  - selected new equipment
  - identified problems and proposed ergonomic design changes to equipment & procedures.

Example: Large Petroleum Distribution Company in U.S.

Macro- and Micro-ergonomics Intervention*

Results

	Reductions After 2 years	Reductions After 9 Years
Motor Vehicle Accidents	51%	63%
Industrial Accidents	54%	70%
Lost Workdays	94%	97%

$ 60,000 savings per year in petroleum delivery costs.

* Imada (2002)

Example: Macroergonomic Approach to Implementing TQM at L.L. Bean

Macro- and Micro-ergonomics Intervention*

- Company ergonomists read my writings on macroergonomics and saw it as a potential methodology for implementing TQM.

- Used methods similar to Imada's in Petroleum distribution company example.

Example: Macroergonomic Approach to Implementing TQM at L.L. Bean

Macro- and Micro-ergonomics Intervention*

Results

- 70% reduction in lost time accidents and injuries achieved in two year period in both production and distribution divisions.

- Other benefits, such as greater employee satisfaction, also realized.

Practical Application of Ergonomics

Conclusion:

Good Ergonomics is Good Economics

And

Is a Key to Optimizing the Effectiveness of our Armed Forces.